Are There Hallmarks of Child Abuse? II. Non-Osseous Injuries

Charis Kepron, Alfredo Walker, Christopher M. Milroy

ABSTRACT

Certain conditions have been considered hallmarks of child abuse. Such pathognomonic conditions have led to an inevitable diagnosis of inflicted injury. Forensic pathologists are faced with complex analyses and decisions related to what is and what is not child abuse. In this review, we examine the literature on the specificity of five conditions that have been linked to inflicted injury to varying degrees of certainty. The conditions examined include tears of the labial frena (frenula), cigarette burns, pulmonary hemorrhage and intraalveolar hemosiderin-laden macrophages as markers of upper airway obstruction, intraabdominal injuries, and anogenital injuries and postmortem changes.

Analysis of the literature indicates that frena tears are not uniquely an inflicted injury. Cigarette burns are highly indicative of child abuse, though isolated cigarette burns may be accidental. Pulmonary hemorrhage is seen more commonly in cases with a history suggestive of upper airway obstruction, but is not diagnostic in an individual case. Hemosiderin-laden macrophages may be seen in cases with inflicted injuries and in natural deaths. Abdominal injuries may be seen in accidents and from resuscitation, though pancreato-duodenal complex injuries in children under five years of age are not reported to be seen in falls or resuscitation. The understanding of anogenital injuries is increasing, but misunderstanding of postmortem changes has led to miscarriages of justice. *Acad Forensic Pathol.* 2016 6(4): 591-607

AUTHORS

Charis Kepron MD MSc FRCPC, Ontario Forensic Pathology Service - Eastern Ontario Regional Forensic Pathology Unit and University of Ottawa - Pathology and Laboratory Medicine

Roles: Project conception and/or design, data acquisition, analysis and/or interpretation, manuscript creation and/or revision, approved final version for publication, accountable for all aspects of the work, writing assistance and/or technical editing.

Alfredo Walker MB.BS FRCPath DMJ (Path) MFFLM MCSFS, University of Ottawa - Forensic Pathology

Roles: Project conception and/or design, manuscript creation and/or revision, approved final version for publication, accountable for all aspects of the work.

Christopher M. Milroy MBChB MD LLB BA LLM FRCPath FFFLM FRCPC DMJ, The Ottawa Hospital - Anatomical Pathology

Roles: Project conception and/or design, data acquisition, analysis and/or interpretation, manuscript creation and/or revision, approved final version for publication, accountable for all aspects of the work, general supervision, writing assistance and/or technical editing.

CORRESPONDENCE

Christopher M. Milroy MD, 501 Smyth Road, Ottawa ON Canada K1H 8L6, c.milroy@btopenworld.com

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INTRODUCTION

The investigation of child abuse is a central part of forensic pathology and is often one of the most contested areas of practice that the forensic pathologist faces. Certain patterns of pathology have been considered diagnostic evidence of child abuse. With a move to evidence-based medicine, what have previously been considered diagnostic features can become questioned and what were once thought to be obvious, such as color of bruising as an aid to aging or the determination of time of death, have become less certain. This paper examines several areas that present to forensic pathologists, and other practitioners, that may have been considered pathognomonic of inflicted injury to a child. Not all areas of child abuse are discussed, but the topics of frena (frenula) tears, cigarette burns, pulmonary hemorrhage and intraalveolar macrophages in infants, abdominal trauma, and appearances of the genitalia and sexual abuse are discussed and the specificity to abuse analyzed.

DISCUSSION

Tears of the Labial Frena

Historically, lacerations of the labial frena in children were regarded as virtually diagnostic of inflicted injury to the mouth (1, 2), and to this day, many pediatricians believe that such injuries are pathognomonic of abuse in nonambulatory children (3). The mechanism of injury is thought to involve either direct blows to the mouth (punches or slaps) or the forceful insertion of objects into the mouth, such as spoons, bottles, or pacifiers (3-7). Popular forensic pathology textbooks also highlight the importance of identifying frenal lacerations at autopsy as indicators of inflicted injury in the pediatric population (4-6), although many rightly include the caveat that these injuries can have causes other than inflicted trauma (7-9).

Injuries to the head and face are common in physically abused children, with incidence rates of 48-75% quoted in various studies on the topic (2, 10-13). The reported prevalence of intraoral injury in abused children is considerably lower, with rates as low as 0.5%

and as high as 12.4% in the studies reviewed (10-13). Although it is a common sense inference that intraoral injuries will represent only a subset of all injuries to the head and neck seen in physically abused children, it has been theorized that the rates of intraoral injury may be higher than reported due to the fact that dental professionals are rarely involved in the assessment of suspected child abuse and neglect (10, 11). Physicians and nurses involved in child protection cases have a relative lack of familiarity with the oral cavity as compared with dentists; therefore, it is possible that many intraoral injuries are being overlooked in living victims of child abuse (10). The frequency of trauma to the face and mouth in the physically abused child is thought to relate to the accessibility of head and face as well as to the association between the mouth and activities such as feeding, speaking, and crying (3, 14).

In spite of the importance placed on the recognition and documentation of frenal injuries in children, there is a surprising lack of literature on the topic. Many of the studies examining the incidence of orofacial trauma in child abuse do not distinguish frenal lacerations from other injuries to the mouth (11, 13); therefore, the true incidence of this finding in both fatal and non-fatal cases of child abuse is not known. From the studies that do separate labial frenal lacerations from other intraoral trauma, the incidence appears low. In a retrospective study of 230 children with identified trauma to the head, face and neck, only one lacerated labial frenum was documented (which also represented the only intraoral injury documented) (10). Another paper reported 511 cases of children suffering from suspected physical abuse, 75.5% of which had injuries to the head, face, mouth, or neck. Only two lacerated labial frena were identified in this cohort, but it was not clear if these injuries were in the same child or two different children (12). It was also not clear what proportion of cases had physical abuse confirmed as the cause of the injuries. The authors of both of these studies suggested that intraoral injuries were likely underrepresented, possibly due to the injuries being overlooked by the examining professionals. A systematic review of torn labial frenum and other intraoral injuries published by the Welsh Child Protection Systematic Re-

view Group concluded that, based on the literature reviewed at the time, “*It is impossible...to ascribe a probability of abuse for a torn labial frenum*” (15). It was also noted that in the cases with torn labial frena where abuse was confirmed as the cause, the children had suffered serious abuse and had extensive associated injuries (15). This finding has been confirmed in subsequent case reports (16, 17). An earlier literature review also concluded that there was insufficient evidence to determine the sensitivity and specificity of a torn frenum as an indicator of nonaccidental injury in children (18). Overall, the most common injury to the mouth seen in confirmed cases of child abuse is injury to the lips (laceration or bruising), not labial frenal tears (15).

Tears of the labial frena in children are not pathognomonic of inflicted injury; especially in those who are ambulatory. In a retrospective review of cases of children presenting to a pediatric emergency department over a 12-month period, 593 children under the age of 13 years were identified as having facial and/or intraoral trauma. Of these, 21 (3.5%) had frenal lacerations. The median age of the children with frenal injury was 19 months, and in all cases, the circumstances of the injury were thought to be accidental in nature. The most common reported mechanism of injury was a simple fall from a standing height (16 of 21 cases), while falls from objects such as furniture or toys and collision with a chair were also reported (four and one of 21 cases, respectively) (19). In their study on cardiopulmonary resuscitation-(CPR) related injuries and homicidal blunt abdominal trauma in children, Price et al. identified one child in their control group of natural deaths who had sustained a lacerated frenum from oral intubation (20). Further details (including the age of the child in question) were not provided. Of note, five out of 33 children in their series (15.2%) who had died as a result of homicidal blunt abdominal trauma also had frenal lacerations. Morrison et al. reported a case of a 3.5 year old girl who was the unrestrained front seat passenger in a car who was killed when the vehicle veered off road and the front seat airbags deployed (21). The child sustained numerous injuries to the head and neck that included lacerations of the lower lip and the upper and lower labial frena. Many of

the injuries were attributed to the impact between the child’s face and the rapidly deployed airbag.

Injuries to the mouth attributable to cardiopulmonary resuscitation have been described (20, 22-24); however, most of the sources do not distinguish frenal tears and refer only to injury to the lips, oropharynx, or oral mucosal surfaces. Therefore, the true incidence of CPR-related frenal injury cannot be stated with any confidence. In one study that looked at the incidence of CPR-related injury in childhood fatalities (not related to obvious trauma or congenital abnormality), nine of 153 children (5.9%) who were subject to resuscitative maneuvers sustained injuries to the lip and 18 of 153 (11.8%) sustained injury to the “airway.” Whether any of these injuries involved the oral mucosal surfaces or labial frena is not specified (25).

Iatrogenic frenal injury has also been described in a 39-week gestational age neonate who sustained a laceration of the upper labial frenum during a forceps-assisted Caesarean delivery (26).

In addition to the nonabusive causes of labial frenal tears, the forensic pathologist must also be aware of possible nontraumatic mimics. Congenital abnormalities such as hypertrophic frenum, midline sinus of the upper lip, and midline diastema could be misinterpreted as healing injury (15, 27, 28). Histologic examination of the abnormal area will help distinguish acute or healing injury from congenital abnormalities, as the histologic hallmarks of trauma (e.g., acute hemorrhage, inflammatory infiltrates, hemosiderin-laden macrophages and/or fibrous tissue deposition) will not be present in nontraumatized tissue (**Images 1 through 3**).

In conclusion, while a torn labial frenum in isolation is not diagnostic of child abuse, infants or young children presenting with this injury must be investigated thoroughly. In preambulatory children where there is no reasonable explanation proffered for the injury, a full examination with appropriate imaging studies should be performed. In living children, examination of the mouth and teeth by a dentist with expertise in the care of children should be considered. In the au-

Image 1: Acute laceration of the upper labial frenum in a two-year old boy. The injury reportedly resulted from a fall down a set of carpeted stairs. Multiple other injuries, including a lacerated liver and a humeral fracture were present. The cause of death was blunt force injury to the head.

Image 2: Laceration of the upper labial frenum in a young child with signs of healing.

topsy population, any child with an acute or healing frenal injury should undergo a complete radiographic skeletal survey and the abnormal area of the oral mucosa should be excised for histologic examination. This will allow for confirmation that the finding is a result of trauma, and will enable the pathologist to offer an opinion on the timing of the injury.

Cigarette Burns

Burns may be deliberately inflicted on a child and are said to be present in 5-22% of physically abused children (29). One of the types of burn seen in child abuse is the cigarette burn (**Image 4**), which are “*not one of the normal hazards of a young child’s life*” (30).

Fuller-Marquardt and colleagues state “*full thickness cigarette burns prove an intentional infliction*” (31) and indicate child abuse. Cigarette burns are an uncommon form of child abuse (32). In a review of 165 accidental burns and 32 inflicted burns, Hobbs reported no accidental cigarette burns, but three of the 32 inflicted burns were from cigarettes (33). They are reported to be most commonly present on the face, hands, and feet, and may be grouped (29).

Inflicted cigarette burns are described as a circular punched-out lesion 7-10 mm in diameter that have a deep central crater. As these are full-thickness burns, they heal with a circular scar. When accidental, they are reported as tending to be oval or eccentric and

Image 3: Histology of the frenal tear in **Image 1** showed extensive acute hemorrhage with early acute inflammatory infiltrates, indicating a period of survival after the injury was sustained (H&E, x100).

more superficial, as there is usually less contact as the child brushes up against the cigarette (29). Causing a cigarette burn with scar formation is stated to require the glowing end of the cigarette to be in contact with the skin for two to three seconds (31). Cigarette burns must be distinguished from impetigo, which will have crusting at the edges and is an epidermal lesion that heals without scarring (34). Forensic pathologists can carry out histology on suspected cigarette burns to show the depth of the lesion.

The presence of cigarette burns in a young child therefore raises strong implications of deliberate infliction. A single injury may be from accidental contact, especially if not circular and deep. Multiple burns in a young child are indicative of intentional infliction. However, there is a lack of literature differentiating

inflicted from accidental cigarette burns. In an analysis of the literature on child abuse, Maguire has pointed out a lack of comparative studies between intentional and accidental cigarette burns (35) and in a 2013 article, Kemp et al. again pointed out the lack of comparative studies (36). In this review, Kemp et al. reported 18 cases of cigarette burns in the literature, with their location on the face, back, legs, and palm and back of the hand. One child presented with “*impetigenised*” circular lesions on the face, but also had further lesions on the back and limbs (36).

Multiple cigarette burns remain highly specific for child abuse. A single burn may be accidental. When cigarette burns are present, there is a high likelihood of other inflicted injuries being present (36).

Image 4: Cigarette burn. Used with permission of Dr. Evan Matshes from (5).

Pulmonary Hemorrhage and Hemosiderin as Evidence of Asphyxia

In performing an autopsy on a sudden unexpected death of an infant, histologic examination of the lung is a standard part of the autopsy. Typically, the findings are nonspecific, with congestion and often some degree of intraalveolar hemorrhage present (37). Special stains, including Perls' stain for hemosiderin, may be performed. It has been proposed that the presence of intraalveolar hemorrhage (**Image 5**) can be an indicator of an asphyxial death, and intraalveolar hemo-

siderin laden macrophages (**Image 6**) can occur from previous episodes of apparent life-threatening events (ALTE) and airway obstruction (38, 39).

In a study of 62 consecutive infant deaths, Yukawa and colleagues used image analysis of lung histology to quantify the amount area of alveolar hemorrhage in lung sections and compared them to the history/scene information (40). Deaths classified as sudden infant death syndrome (SIDS) were then subclassified into typical, atypical, cardiac, infection, possible overlaying, and possible nonaccidental injury cases. They

Image 5: Intraalveolar hemorrhage in an infant (H&E, x100).

reported that with deaths where upper airway obstruction was suspected, whether accidental or deliberate, there was an increase in intraalveolar hemorrhage as measured by digital analysis. They noted that observers tended to underestimate the amount of hemorrhage present without the use of digital image analysis. They stated that intraalveolar hemorrhage was not a specific marker of upper airway obstruction, but noted its greater frequency with a history suggestive of upper airway obstruction. They noted the problem of classification of SIDS and wondered whether true SIDS had been overestimated.

Krous and colleagues examined intraalveolar hemorrhage in 444 infant deaths, where 405 cases were classified as SIDS and 39 as suffocation, of which three were intentional (41). They noted increased grades of pulmonary hemorrhage in 33% of suffocation cases and only 11% of SIDS cases. They stated that among the SIDS cases, those with a higher grade of pulmonary hemorrhage were more likely to bed-share. They concluded that the degree of pulmonary hemorrhage cannot be used in isolation to determine the cause or manner of death. A study from London, UK also showed an increase in intrapulmonary hem-

Image 6: Intraalveolar hemosiderin-laden macrophages (Perls' stain, x400).

orrhage with cosleeping (42). It should be pointed out that many jurisdictions would not classify bedsharing (cosleeping) cases as SIDS and may be classified as asphyxia-related deaths. The manner of death in these cases may vary from natural, accident, or undetermined depending on jurisdictional policy in determining manner of death.

A second histologic feature that has been examined in these cases is the presence of hemosiderin-laden macrophages (**Image 6**) (42, 43). These have been seen in cases where there was a history of previously induced upper airway obstruction (39). Studies have been conducted to examine the frequency of intraalveolar hemosiderin in infants (43-49). These studies indicate that hemosiderin-laden macrophages are present in a small but significant number of cases classified as SIDS. In a study of 536 infant autopsies by Weber and colleagues, 29 cases (5%) had intraalveolar hemosiderin-laden macrophages (47). They did note, however, that in nine of the 29 cases (31%) there were features of nonaccidental injury (NAI) compared with nine of 242 cases (4%) of unexplained infant death without features of NAI or other contributory evidence.

The literature thus shows that pulmonary intraalveolar hemorrhage and intralveolar hemosiderin-laden macrophages are not diagnostic of upper airway obstruction or previous episodes of airway obstruction, though there is an increased incidence of pulmonary hemorrhage in cases where death was considered to be due to overlaying/bedsharing and possible imposed upper airway obstruction. The problem of classification of SIDS versus other causes also hampers comparing studies in this area.

Abdominal Injury in Childhood

Traumatic injuries account for over 20 000 deaths annually in the U.S. in children over one year of age (50). After head injury, the main fatal inflicted injury in childhood is abdominal injury (51). Patterns of injury vary with age and physical ability of the child. Abdominal injuries may also be accidental, but the history will typically be obvious in such accidents, with motor vehicle collisions being the most common

reason. Noninflicted mechanisms other than vehicular collisions may include falls, kicks by animals, and handlebar injuries (52, 53). In the U.S. the leading manner of death in children between one and 19 years of age from abdominal injury is accident, with homicide as the second most common (52). Blunt abdominal injuries have a 50% mortality and inflicted injuries carry a worse prognosis than accidental mechanisms (54-56).

A variety of solid and hollow structures may be damaged in child abuse (57). External bruising is often absent despite major internal organ damage (58-59). The most common organ damaged is the liver. The extent of liver damage varies from contusional damage and subcapsular hematoma formation to lacerations with complete bisection of the liver. The adrenal gland may be contused in inflicted injury or show secondary hemorrhage from a stress reaction (60). Mesenteric fibrosis has been reported as evidence of previous abdominal injury (61). Colonic injury is rare and penetrating injuries through the abdominal wall are more common (62).

The duodenum and pancreas have been highly associated with child abuse in younger children. The duodenum is reported to be injured in 4-6% of abdominal trauma and may rupture in the peritoneal or retroperitoneal segments (63). It is often associated with pancreatic injuries (64). Trauma may also result in duodenal wall hematoma and this may present as bowel obstruction (65). Nontraumatic duodenal hematoma has been reported in a patient with a bleeding disorder (66). Abdominal trauma may cause rupture of the jejunum and ileum. The most commonly injured area is the jejunum, especially near the ligament of Treitz (67). Mesenteric laceration and avulsion commonly accompany small bowel injury (53, 68). Delayed presentation is not uncommon, especially with deliberately inflicted injury.

The duodenum and pancreas may be injured in falls and inflicted injury. This can result in contusions or lacerations. The pancreas may be transected. Previous injury may be identified by hemosiderin and fibrosis (69). Sequelae include peritonitis, pancreatitis, and pseudocyst formation. One mechanism of accidental injury is a handlebar injury from cycling incidents. In inflicted injury, the abdomen may be kicked or

punched. Pancreaticoduodenal injury has not been reported from a fall in the under five age group (70). Other than falls, which are a common postulated mechanism to explain child abuse, resuscitation may be proposed as the mechanism of injury.

Significant injury may occur from resuscitation (51). The main injuries reported have been gastric perforation, liver and splenic laceration, hemoperitoneum, pneumoperitoneum, and retroperitoneal hematoma (51). An examination of 204 children up to 14 years of age who underwent resuscitation found one hematoma of the spleen with no major visceral injuries detected (71). In another study of 33 child homicides with fatal abdominal injuries, the severity of the injuries in nine children who had not undergone any resuscitation were compared with 24 who had (20). The authors found no difference in the nature or severity of injuries between the two groups. In an analysis of 324 natural deaths in children who had undergone resuscitation, no abdominal injuries were found in any of the children.

Therefore, when it comes to examination of abdominal injuries, absent an obvious history of accidental trauma such as a motor vehicle collision, there is a very high specificity for inflicted injury when damage to the pancreaticoduodenal anatomical complex is present. There is no evidence in the literature that resuscitation or a fall would cause these injuries in a child under five years of age.

Anogenital Injuries in Pediatric Sexual Abuse

When confronted with a case of suspected child sexual abuse, the forensic pathologist must proceed with caution. Anogenital injury at autopsy has a differential diagnosis, and careful macroscopic evaluation with appropriate ancillary tests is essential in order to make the correct diagnosis. As an illustration of these principles, a notorious miscarriage of justice occurred in the province of Ontario, Canada, when a 22-year-old man was charged and convicted of first-degree murder in the death of his 4-year-old niece. A community-based anatomical pathologist performed the autopsy and made two serious errors: interpretation of anal dilation as evidence of chronic sexual abuse,

and misdiagnosis of Tardieu spots in the face and anterior neck as evidence of mechanical asphyxiation. These errors were compounded when the case was reviewed by a pediatric pathologist with no specific training in forensic pathology and various clinicians with expertise in child maltreatment; they all agreed with the original pathologist's conclusions. Postconviction review of the case by a forensic pathologist 11 years after the child's death showed that the pathological "evidence" used in the case against the child's uncle was no more than postmortem artifact, and the conviction was ultimately quashed (72, 73).

This case demonstrates an all too common pitfall in autopsy pathology: the misinterpretation of postmortem changes as evidence of inflicted injury. This pitfall was identified by Dr. Alan Moritz as one of the classical mistakes in forensic pathology in his seminal paper first published in 1956 (74), where he specifically cautioned the pathologist against misinterpreting "*abnormal distensibility of the rectum, vulva and vagina*" at autopsy as evidence of antemortem rape or sodomy. In their often-cited paper from 1996, McCann et al. describe the anal and perianal findings in 65 autopsies performed on children and adolescents from birth to 17 years of age (75). Seventy-seven percent of their subjects showed some dilation of the anal sphincter, and in 32%, the pectinate line was exposed. There was a positive association between the age of the subjects and the anteroposterior dimension of the anal orifice, and there was an increased likelihood of anal dilation in cases where the child had suffered significant injury to the central nervous system prior to death (75). Postmortem dilation of the anus and vagina (**Image 7**) is a phenomenon that is now well-recognized by forensic pathologists (73, 76-80), and misinterpretation of this finding is rare in cases where the autopsy was performed by an appropriately trained pathologist.

Although there are many papers and textbooks discussing the anogenital findings in abused and non-abused living children (81-90), the medical literature shows a surprising dearth of evidence regarding the postmortem anogenital findings in cases of acute or chronic sexual abuse. Very few papers deal with the specific issues involved in the investigation of possi-

ble sexual abuse in postmortem cases (73, 75, 80, 91), therefore the pathologist will need to rely on the first principles of anatomy, histopathology, and pathophysiology to guide their examination.

The most important tool the forensic pathologist must have in their armamentarium is a good understanding of the normal anatomy and development of the genitals and perineum in infants, children, and adolescents. This is to ensure that normal anatomical variants are interpreted correctly and that the abnormalities are properly documented. All abnormalities should be properly photographed (81). If the pathologist has been informed of allegations of sexual abuse, good quality photographs should be taken, regardless of the autopsy results, as negative findings can be as important as positive ones. Swabs of the oral cavity, vagina, and/or rectum for semen should be obtained; the identification of sperm or semen in the body of a child who is too young to have legally consented to sexual activity is considered definitive evidence of sexual abuse if the donor was an abuser by virtue of their age or relationship to the child (81, 92). Pregnancy also represents proof of sexual activity and tissue can be sent for DNA testing to establish paternity; therefore, the pathologist must be certain to always open the uterus and carefully examine the Fallopian tubes (to exclude the possibility of an ectopic pregnancy) in postmenarchal girls. The standard bivalve method of opening the uterus used in surgical pathology is recommended, as opposed to the breadloaf method of serially sectioning. Cuts extending along the lateral margins of the uterus from the cervical os to the cornu should be made with scissors and the uterus opened to expose the endometrial cavity. When there is no macroscopic evidence of pregnancy, consider putting through a section of endometrium for histologic examination to provide proof that the girl was not pregnant at the time of her death. It is possible to measure human chorionic gonadotropin (HCG) in postmortem blood or urine, which will provide biochemical confirmation of pregnancy in the absence of other pathological conditions that can lead to an elevated HCG level (such as choriocarcinoma). If these fluids are not available, β -HCG levels can be measured in postmortem bile or vitreous fluid (93). Although the presence of sexually

transmitted infections (STI) is good evidence of sexual contact prior to death (81, 92), findings such as vaginal discharge, erythema, and skin lesions have a differential diagnosis and care must be taken not to overcall findings with a benign etiology. The pathologist should not diagnose an STI at autopsy without histologic and/or laboratory (bacteriology or virology)

Image 7: Postmortem anal dilatation mistaken for sexual abuse.

gy) confirmation, and should always keep in mind that certain STIs (such as syphilis, human papillomavirus, and herpesvirus infections) can be transmitted to an infant before or during childbirth (81, 92, 94).

When true trauma to the anogenital area is identified at autopsy, the forensic pathologist will likely be asked to offer an opinion on the mechanism of injury. Injuries to the genitals or perineum should not be considered diagnostic of abuse, as there are scenarios where such injuries can occur accidentally. Boos et al. reported a case series of four children who were involved in motor vehicle collisions in which the wheel of the vehicle passed longitudinally over the child's torso (95). All four presented with anogenital injuries including acute anal lacerations, penile hematomas, perineal abrasions, hymenal lacerations, vaginal lacerations and abrasions, and lacerations and hematomas of the labia majora, labia minora, and posterior fourchette. The mechanism of the anogenital injuries in these cases was thought to involve either the high intraabdominal pressure resulting from the wheel passing over the children's abdomens or shearing forces resulting from the traction on the skin from the tires passing over the pelvis. Straddle injuries in girls are relatively common and can result in bruises, abrasions, and lacerations of the vulva and perineum (96) and there have been reported cases of accidental penetrating injury to the hymen in young girls (96, 97). Bruising and abrasion to the penis can occur when toilet seats fall on young boys or if the penis is caught in a zipper (96). There is a case report of an unusual injury in a 9-year-old girl who sustained vaginal lacerations as a result of a fall while water skiing. The lacerations were due to the forceful entry of water into the vagina under high pressure (98). In general, accidental injuries to the genitals and perineum can occur, but the history provided must be compatible with the pattern of injury seen. Typically, isolated accidental anogenital injury does not result in the death of the child; therefore, these cases will rarely come to the attention of the forensic pathologist.

Anogenital injuries resulting from sexual abuse that prove fatal are rare; typically, child victims of sexual abuse who are presenting for autopsy have died of some

form of asphyxiation (e.g., smothering, strangulation) or blunt impact head trauma (79, 99, 100). Children who die from anogenital trauma typically suffer very severe lacerations of the vagina or rectum, resulting in fatal peritonitis or exsanguination (79, 101, 102).

Natural diseases can mimic the effects of acute or chronic sexual abuse, and the forensic pathologist should have a low threshold for consulting clinical colleagues, such as pediatricians with expertise in child maltreatment, if there is a possibility of an underlying organic condition causing the concerning findings. Examples include vascular malformations mimicking bruises (80), perianal bleeding due to midgut volvulus (103), perianal excoriations due to ectodermal dysplasia clefting syndrome (103), urethral prolapse resulting in perineal bleeding (79, 92), vulvovaginitis mimicking sexually transmitted infection (79, 81), lichen sclerosis mimicking chronic scarring (92), anal laceration resulting from chronic constipation (**Images 8 through 10**), and others. The value of histologic examination of possible injuries should be emphasized, as this will easily distinguish many natural disease processes from the acute or chronic effects of trauma.

Image 8: Anal laceration from chronic constipation. This should not be mistaken for sexual abuse.

In addition to the phenomenon of postmortem anal dilation discussed above, other common postmortem changes can mimic anogenital trauma. Livor mortis involving the vulva or hymen can be misinterpreted as bruising (73, 80), and blood within the anus or vagina may be present as a consequence of medical therapy in children who underwent a resuscitation attempt or spent some time in hospital prior to death (91). Artfactual disruption of the rectal mucosa that occurred at the time of histologic slide preparation was misinterpreted as evidence of acute rectal injury in the case described at the beginning of this section (73), and review of the relevant slides by a group of experienced forensic pathologists confirmed there was no pathological evidence (e.g., acute hemorrhage or inflammation) of acute rectal trauma. If the pathologist identifies anogenital lesions at autopsy that are suspicious for acute or healing trauma, it is imperative that appropriate histologic sampling be undertaken in order to rule out possible postmortem artifacts or other benign mimics.

If possible injuries are identified in the vaginal canal, cervix or rectum, pelvic exenteration and formalin fixation of the tissues followed by thorough examination of the involved area with histologic sampling should be undertaken. The opportunity to assess tissues microscopically is a marked advantage that forensic pathologists have over our clinical colleagues, and its importance cannot be understated in the evaluation of suspected anogenital injury in children.

CONCLUSION

While many patterns of pathology can be indicative of child abuse, there may be an alternate explanation that needs to be explored. As discussed above, a single cigarette burn on a child could be accidental, but multiple cigarette burns are indicative of inflicted injury. Similarly, trauma to the pancreaticoduodenal complex can be accidental or inflicted. However when history is taken into account, these patterns of causation are eas-

Image 9: Photomicrographs of the apparent laceration in **Image 8** show superficial mucosal erosion with no trauma to the underlying soft tissue (H&E, x25).

Image 10: Photomicrographs of the apparent laceration in **Image 8** at high power. There is congestion of the blood vessels with scant acute hemorrhage and very little associated inflammation. Hemosiderin-laden macrophages are present, indicating recurrent injury to the area (H&E, x200).

ily distinguishable. Pathologists have advantages over clinicians with respect to fatal child abuse in being able to perform microscopy on injuries, which adds information not available to clinicians. They also have the training and experience of postmortem changes when it comes to identifying anogenital changes at autopsy that have been mistaken for sexual abuse. However, it must also be acknowledged that in many areas where certain types of injury have been held to be hallmarks of child abuse, there has been limited discussion in the literature and more data are needed.

REFERENCES

- 1) Cameron JM, Rae LJ. Atlas of the battered child syndrome. New York: Churchill Livingstone; 1975. 90 p.
- 2) Tate RJ. Facial injuries associated with the battered child syndrome. *Br J Oral Surg*. 1971 Jul;9(1):41-5. PMID: 5315395. [https://doi.org/10.1016/s0007-117x\(71\)80007-0](https://doi.org/10.1016/s0007-117x(71)80007-0).
- 3) Jenny C. Oral injuries. In: Child abuse and neglect : diagnosis, treatment, and evidence. St. Louis: Elsevier; 2011. p. 334.
- 4) Saukko P, Knight B. Damage to eyes, ears and mouth. In: Knight's forensic pathology. 3rd ed. London: Arnold; 2004. p. 473.
- 5) Dolinak D, Matshes E, Lew E. Blunt force injuries. In: Forensic Pathology: principles and practice. Burlington: Elsevier; 2005. p. 377.

- 6) Spitz WU. Autopsy findings: external examinations. In: Spitz and Fisher's medicolegal investigation of death: guidelines for the application of pathology to crime investigation. 4th ed. Springfield (IL): Charles C. Thomas; 2006. p. 373.
- 7) Byard RW. Skin and soft tissue injury. In: Sudden death in the young. Cambridge (UK): Cambridge University Press; 2010. p. 106.
- 8) Leestma JE. General autopsy. In: Forensic neuropathology. 3rd ed. Boca Raton: CRC Press; 2014. p. 601.
- 9) DiMaio D, DiMaio VJ. Infanticide and child murder. In: Forensic pathology. 2nd ed. Boca Raton: CRC Press; 2001. p. 339.
- 10) Cairns AM, Mok JY, Welbury RR. Injuries to the head, face, mouth and neck in physically abused children in a community setting. *Int J Paediatr Dent*. 2005 Sep; 15(5):310-8. PMID: 16128994. <https://doi.org/10.1111/j.1365-263X.2005.00661.x>.
- 11) Naidoo S. A profile of the oro-facial injuries in child physical abuse at a children's hospital. *Child Abuse Negl*. 2000 Apr; 24(4):521-34. PMID: 10798841. [https://doi.org/10.1016/s0145-2134\(00\)00114-9](https://doi.org/10.1016/s0145-2134(00)00114-9).
- 12) da Fonseca MA, Feigal RJ, ten Bensel RW. Dental aspects of 1248 cases of child maltreatment on file at a major county hospital. *Pediatr Dent*. 1992 May-Jun; 14(3):152-7. PMID: 1528783.
- 13) Cavalcanti AL. Prevalence and characteristics of injuries to the head and orofacial region in physically abused children and adolescents—a retrospective study in a city of the Northeast of Brazil. *Dent Traumatol*. 2010 Apr; 26(2):149-53. PMID: 20070347. <https://doi.org/10.1111/j.1600-9657.2009.00859.x>.
- 14) Symons AL, Rowe PV, Romaniuk K. Dental aspects of child abuse: review and case reports. *Aust Dent J*. 1987 Feb; 32(1):42-7. PMID: 2887154. <https://doi.org/10.1111/j.1834-7819.1987.tb01272.x>.
- 15) Maguire S, Hunter B, Hunter L, et al. Diagnosing abuse: a systematic review of torn frenum and other intra-oral injuries. *Arch Dis Child*. 2007 Dec; 92(12):1113-7. PMID: 17468129. PMID: PMC2066066. <https://doi.org/10.1136/adc.2006.113001>.
- 16) Thackeray JD. Frena tears and abusive head injury: a cautionary tale. *Pediatr Emerg Care*. 2007 Oct; 23(10):735-7. PMID: 18090110. <https://doi.org/10.1097/PEC.0b013e3181568039>.
- 17) Starr M, Klein EJ, Sugar N. A perplexing case of child abuse: oral injuries in abuse and physician reporting responsibilities. *Pediatr Emerg Care*. 2015 Aug; 31(8):581-3. PMID: 25426684. <https://doi.org/10.1097/PEC.0000000000000286>.
- 18) Teece S, Crawford I. Best evidence topic report. Torn frenulum and non-accidental injury in children. *Emerg Med J*. 2005 Feb; 22(2):125. PMID: 15662069. PMID: PMC1726658. <https://doi.org/10.1136/emj.2004.022079>.
- 19) Kidd AJ, Beattie TF, Campbell-Hewson G. Frenal injury in children is not pathognomonic of non-accidental injury. *Emerg Med J*. 2010 Jan; 27(1):52. PMID: 20029009. <https://doi.org/10.1136/emj.2009.075051>.
- 20) Price EA, Rush LR, Perper JA, Bell MD. Cardiopulmonary resuscitation-related injuries and homicidal blunt abdominal trauma in children. *Am J Forensic Med Pathol*. 2000 Dec; 21(4):307-10. PMID: 11111786. <https://doi.org/10.1097/00000433-200012000-00001>.
- 21) Morrison AL, Chute D, Radentz S, et al. Air bag-associated injury to a child in the front passenger seat. *Am J Forensic Med Pathol*. 1998 Sep; 19(3):218-22. PMID: 9760084. <https://doi.org/10.1097/00000433-199809000-00003>.
- 22) Olds K, Byard RW, Langlois NE. Injuries associated with resuscitation - an overview. *J Forensic Legal Med*. 2015 Jul; 33:39-43. PMID: 26048495. <https://doi.org/10.1016/j.jflm.2015.04.003>.
- 23) Krischer JP, Fine EG, Davis JH, Nagel EL. Complications of cardiac resuscitation. *Chest*. 1987 Aug; 92(2):287-91. PMID: 3608599. <https://doi.org/10.1378/chest.92.2.287>.
- 24) Saukko P, Knight B. Resuscitation artefacts at autopsy. In: Knight's forensic pathology. 3rd ed. London: Arnold; 2004. p. 40-1.
- 25) Ryan MP, Young SJ, Wells DL. Do resuscitation attempts in children who die, cause injury? *Emerg Med J*. 2003 Jan; 20(1):10-2. PMID: 12533359. PMID: PMC1725991. <https://doi.org/10.1136/emj.20.1.10>.
- 26) Gurung H, Cohn A. Labial frenum tear from instrumental delivery. *Arch Dis Child*. 2015 Aug; 100(8):773. PMID: 25809343. <https://doi.org/10.1136/archdischild-2014-307733>.
- 27) Asahina I, Sakakibara T, Miyashin M, et al. Congenital midline sinus of the upper lip: case report and review of literature. *Cleft Palate Craniofac J*. 1997 Jan; 34(1):83-5. PMID: 9003918. [https://doi.org/10.1597/1545-1569\(1997\)034%3C0083:CMSOTU%3E2.3.CO;2](https://doi.org/10.1597/1545-1569(1997)034%3C0083:CMSOTU%3E2.3.CO;2).
- 28) Chan L, Hodes D. When is an abnormal frenulum a sign of child abuse? *Arch Dis Child*. 2004 Mar; 89(3):277. PMID: 14977712. PMID: PMC1719841. <https://doi.org/10.1136/adc.2003.031534>.
- 29) Kos L, Shwayder T. Cutaneous manifestations of child abuse. *Pediatr Dermatol*. 2006 Jul-Aug; 23(4):311-20. PMID: 16918624. <https://doi.org/10.1111/j.1525-1470.2006.00266.x>.
- 30) Keen JH, Lendrum J, Wolman B. Inflicted burns and scalds in children. *Br Med J*. 1975 Nov 1; 4(5991):268-9. PMID: 1192018. PMID: PMC1675100. <https://doi.org/10.1136/bmj.4.5991.268>.
- 31) Faller-Marquardt M, Pollak S, Schmidt U. Cigarette burns in forensic medicine. *Forensic Sci Int*. 2008 Apr 7; 176(2-3):200-8. PMID: 17976935. <https://doi.org/10.1016/j.forsciint.2007.09.006>.
- 32) Hobbs CJ. ABC of child abuse. Burns and scalds. *BMJ*. 1989 May 13; 298(6683):1302-5. PMID: 2500207. PMID: PMC1836519. <https://doi.org/10.1136/bmj.298.6683.1302>.
- 33) Hobbs CJ. When are burns not accidental? *Arch Dis Child*. 1986 Apr; 61(4):357-61. PMID: 3707186. PMID: PMC1777757.
- 34) Wheeler DM, Hobbs CJ. Mistakes in diagnosing non-accidental injury: 10 years' experience. *Br Med J (Clin Res Ed)*. 1988 Apr 30; 296(6631):1233-6. PMID: 3133026. PMID: PMC2545708. <https://doi.org/10.1136/bmj.296.6631.1233>.
- 35) Maguire S. Which injuries may indicate child abuse? *Arch Dis Child Educ Pract Ed*. 2010 Dec; 95(6):170-7. PMID: 20926622. <https://doi.org/10.1136/adc.2009.170431>.
- 36) Kemp AM, Maguire SA, Lumb RC, et al. Contact, cigarette and flame burns in physical abuse: a systematic review. *Child Abuse Rev*. 2013 Jun 28; 23(1):35-47. <https://doi.org/10.1002/car.2278>.
- 37) Hanzlick R. Pulmonary hemorrhage in deceased infants: baseline data for further study of infant mortality. *Am J Forensic Med Pathol*. 2001 Jun; 22(2):188-92. PMID: 11394757. <https://doi.org/10.1097/00000433-200106000-00016>.
- 38) Becroft DM, Lockett BK. Intra-alveolar pulmonary siderophages in sudden infant death: a marker for previous imposed suffocation. *Pathology*. 1997 Feb; 29(1):60-3. PMID: 9094180. <https://doi.org/10.1080/00313029700169554>.
- 39) Milroy CM. Munchausen syndrome by proxy and intra-alveolar haemosiderin. *Int J Legal Med*. 1999; 112(5):309-12. PMID: 10460422. <https://doi.org/10.1007/s004140050255>.
- 40) Yukawa N, Carter N, Rutty G, Green MA. Intra-alveolar haemorrhage in sudden infant death syndrome: a cause for concern? *J Clin Pathol*. 1999 Aug; 52(8):581-7. PMID: 10645227. PMID: PMC500948. <https://doi.org/10.1136/jcp.52.8.581>.
- 41) Krous HF, Chadwick AE, Haas EA, Stanley C. Pulmonary intra-alveolar hemorrhage in SIDS and suffocation. *J Forensic Leg Med*. 2007 Nov; 14(8):461-70. PMID: 17254829. <https://doi.org/10.1016/j.jcfm.2006.10.004>.

- 42) Weber MA, Risdon RA, Ashworth MT, et al. Autopsy findings of co-sleeping-associated sudden unexpected deaths in infancy: relationship between pathological features and asphyxial mode of death. *J Paediatr Child Health*. 2012 Apr; 48(4):335-41. PMID: 22017395. <https://dx.doi.org/10.1111/j.1440-1754.2011.02228.x>.
- 43) Byard RW, Stewart WA, Telfer S, Beal SM. Assessment of pulmonary and intrathymic hemosiderin deposition in sudden infant death syndrome. *Pediatr Pathol Lab Med*. 1997 Mar-Apr; 17(2):275-82. PMID: 9086534. <https://doi.org/10.1080/713601283>.
- 44) Hanzlick R, Delaney K. Pulmonary hemosiderin in deceased infants: baseline data for further study of infant mortality. *Am J Forensic Med Pathol*. 2000 Dec; 21(4):319-22. PMID: 1111789. <https://doi.org/10.1097/00000433-200012000-00004>.
- 45) Schluckebier DA, Cool CD, Henry TE, et al. Pulmonary siderophages and unexpected infant death. *Am J Forensic Med Pathol*. 2002 Dec; 23(4):360-3. PMID: 12464813. <https://dx.doi.org/10.1097/01.PAF.0000035228.91843.26>.
- 46) Jackson CM, Gilliland MG. Frequency of pulmonary hemosiderosis in Eastern North Carolina. *Am J Forensic Med Pathol*. 2000 Mar; 21(1):36-8. PMID: 10739224. <https://doi.org/10.1097/00000433-200003000-00006>.
- 47) Krous HF, Wixom C, Chadwick AE, et al. Pulmonary intra-alveolar siderophages in SIDS and suffocation: a San Diego SIDS/SUDC Research Project report. *Pediatr Dev Pathol*. 2006 Mar-Apr; 9(2): 103-14. PMID: 16813458. <https://dx.doi.org/10.2350/08-05-0088.1>.
- 48) Weber MA1, Ashworth MT, Anthony Risdon R, et al. The frequency and significance of alveolar haemosiderin-laden macrophages in sudden infant death. *Forensic Sci Int*. 2009 May 30; 187(1-3):51-7. PMID: 19329265. <https://dx.doi.org/10.1016/j.forsciint.2009.02.016>.
- 49) Kernbach-Wighton G, Albaloooshi Y, Madea B. The evidential value of intra-alveolar haemosiderin-macrophages in cases of sudden infant death syndrome (SIDS). *Forensic Sci Int*. 2012 Oct 10; 222(1-3):27-32. PMID: 22704554. <https://dx.doi.org/10.1016/j.forsciint.2012.04.030>.
- 50) Gaines BA, Ford HR. Abdominal and pelvic trauma in children. *Crit Care Med*. 2002 Nov; 30(11 Suppl):S416-23. PMID: 12528783. <https://doi.org/10.1097/00003246-200211001-00006>.
- 51) Milroy CM. Forensic pathology of infancy and childhood. New York: Springer; 2014. Chapter 13, Blunt abdominal and thoracic injuries in childhood; p. 291-325.
- 52) Kochanek KD, Kirmeyer SE, Martin JA, et al. Annual summary of vital statistics: 2009. *Pediatrics*. 2012 Feb; 129(2):338-48. PMID: 22291121. PMCID: PMC4079290. <https://dx.doi.org/10.1542/peds.2011-3435>.
- 53) Grosfeld JL, Rescorla FJ, West KW, Vane DW. Gastrointestinal injuries in childhood: analysis of 53 patients. *J Pediatr Surg*. 1989 Jun; 24(6):580-3. PMID: 2738826. [https://doi.org/10.1016/s0022-3468\(89\)80511-1](https://doi.org/10.1016/s0022-3468(89)80511-1).
- 54) Cooper A1, Floyd T, Barlow B, et al. Major blunt abdominal trauma due to child abuse. *J Trauma*. 1988 Oct; 28(10):1483-7. PMID: 3172310. <https://doi.org/10.1097/00005373-198810000-00015>.
- 55) Trokel M, DiScala C, Terrin NC, Sege RD. Blunt abdominal injury in the young pediatric patient: child abuse and patient outcomes. *Child Maltreat*. 2004 Feb; 9(1):111-7. PMID: 14871002. <https://dx.doi.org/10.1177/1077559503260310>.
- 56) Cameron CM, Lazoritz S, Calhoun AD. Blunt abdominal injury: simultaneously occurring liver and pancreatic injury in child abuse. *Pediatr Emerg Care*. 1997 Oct; 13(5):334-6. PMID: 9368247. <https://doi.org/10.1097/00006565-199710000-00009>.
- 57) Hilmes MA1, Hernanz-Schulman M, Greeley CS, et al. CT identification of abdominal injuries in abused pre-school-age children. *Pediatr Radiol*. 2011 May; 41(5):643-51. PMID: 21107556. <https://dx.doi.org/10.1007/s00247-010-1899-9>.
- 58) Holmes JF, Sokolove PE, Brant WE, et al. Identification of children with intra-abdominal injuries after blunt trauma. *Ann Emerg Med*. 2002 May; 39(5):500-9. PMID: 11973557. <https://doi.org/10.1067/mem.2002.122900>.
- 59) Wood J, Rubin DM, Nance ML, Christian CW. Distinguishing inflicted versus accidental abdominal injuries in young children. *J Trauma*. 2005 Nov; 59(5):1203-8. PMID: 16385300. <https://doi.org/10.1097/01.ta.0000196437.07011.b1>.
- 60) Nimkin K, Teeger S, Wallach MT, et al. Adrenal hemorrhage in abused children: imaging and postmortem findings. *AJR Am J Roentgenol*. 1994 Mar; 162(3):661-3. PMID: 8109518. <https://dx.doi.org/10.2214/ajr.162.3.8109518>.
- 61) Byard R W, Heath K. Mesenteric fibrosis—a histologic marker of previous blunt abdominal trauma in early childhood. *Int J Legal Med*. 2010 Jan; 124(1):71-3. PMID: 19205718. <https://dx.doi.org/10.1007/s00414-009-0319-x>.
- 62) Dokucu A, Oztürk H, Yağmur Y, et al. Colon injuries in children. *J Pediatr Surg*. 2000 Dec; 35(12):1799-804. PMID: 11101740. <https://doi.org/10.1053/jpsu.2000.19262>.
- 63) Pokorny WJ, Brandt ML, Harberg FJ. Major duodenal injuries in children: diagnosis, operative management, and outcome. *J Pediatr Surg*. 1986 Jul; 21(7):613-6. PMID: 3525803. [https://doi.org/10.1016/s0022-3468\(86\)80416-x](https://doi.org/10.1016/s0022-3468(86)80416-x).
- 64) Winthrop AL, Wesson DE, Filler RM. Traumatic duodenal hematoma in the pediatric patient. *J Pediatr Surg*. 1986 Sep; 21(9):757-60. PMID: 3772698. [https://doi.org/10.1016/s0022-3468\(86\)80359-1](https://doi.org/10.1016/s0022-3468(86)80359-1).
- 65) DeRose JJ Jr, Diamond S, Bergman K. Spontaneous duodenal hematoma in a patient with Glanzmann's thrombasthenia. *J Pediatr Surg*. 1997 Sep; 32(9):1341-3. PMID: 9314258. [https://doi.org/10.1016/s0022-3468\(97\)90317-1](https://doi.org/10.1016/s0022-3468(97)90317-1).
- 66) Desai KM, Dorward IG, Minkes RK, Dillon PA. Blunt duodenal injuries in children. *J Trauma*. 2003 Apr; 54(4):640-5; discussion 645-6. PMID: 12707524. <https://dx.doi.org/10.1097/01.TA.0000056184.80706.9B>.
- 67) Bruny JL, Bensard DD. Hollow viscous injury in the pediatric patient. *Semin Pediatr Surg*. 2004 May; 13(2):112-8. PMID: 15362281. <https://doi.org/10.1053/j.sempedsurg.2004.01.007>.
- 68) Ng CS, Hall CM, Shaw DG. The range of visceral manifestations of non-accidental injury. *Arch Dis Child*. 1997 Aug; 77(2):167-74. PMID: 9301362. PMCID: PMC1717290. <https://doi.org/10.1136/adc.77.2.167>.
- 69) Dye DW, Peretti FJ, Kokes CP. Histologic evidence of repetitive blunt force abdominal trauma in four pediatric fatalities. *J Forensic Sci*. 2008 Nov; 53(6):1430-3. PMID: 18808370. <https://dx.doi.org/10.1111/j.1556-4029.2008.00883.x>.
- 70) Maguire SA, Upadhyaya M, Evans A, et al. A systematic review of abusive visceral injuries in childhood—their range and recognition. *Child Abuse Negl*. 2013 Jul; 37(7):430-45. PMID: 23306146. <https://dx.doi.org/10.1016/j.chiabu.2012.10.009>.
- 71) Bush CM, Jones JS, Cohle SD, Johnson H. Pediatric injuries from cardiopulmonary resuscitation. *Ann Emerg Med*. 1996 Jul; 28(1):40-4. PMID: 8669737. [https://doi.org/10.1016/s0196-0644\(96\)70137-3](https://doi.org/10.1016/s0196-0644(96)70137-3).
- 72) Goudge ST. Report of the inquiry into pediatric forensic pathology in Ontario [Internet]. Toronto: Ontario Ministry of the Attorney General; 2008 [cited 2016 Oct 7]. 985 p. Available from: <http://www.attorneygeneral.jus.gov.on.ca/inquiries/goudge/report/>.
- 73) Pollanen MS. Forensic pathology and the miscarriage of justice. *Forensic Sci Med Pathol*. 2012 Sep; 8(3):285-9. PMID: 22116733. <https://dx.doi.org/10.1007/s12024-011-9299-5>.
- 74) Moritz AR. Classical mistakes in forensic pathology: Alan R. Moritz (American Journal of Clinical Pathology, 1956). *Am J Forensic Med Pathol*. 1981 Dec; 2(4):299-308. PMID: 7041626. <https://doi.org/10.1097/00000433-198112000-00003>.

- 75) McCann J, Reay D, Siebert J, et al. Postmortem perianal findings in children. *Am J Forensic Med Pathol*. 1996 Dec; 17(4):289-98. PMID: 8947352. <https://doi.org/10.1097/00000433-199612000-00003>.
- 76) Saukko P, Knight B. Genital injuries. In: Knight's forensic pathology. 3rd ed. London: Arnold; 2004. p. 423-4.
- 77) Dolinak D, Matshes E, Lew E. The perianal examination. In: Forensic pathology: principles and practice. Burlington (MA): Elsevier; 2005. p. 475.
- 78) Spitz WU. Investigation of deaths in childhood. In: Spitz and Fisher's medicolegal investigation of death. 4th ed. Springfield (IL): Charles C. Thomas; 2006. p. 375, 405.
- 79) Byard RW. Assessment of cases: autopsy examination. In: Sudden death in the young. Cambridge (UK): Cambridge University Press; 2010. 135-6 pp.
- 80) Ambrosetti F, Palazzo E, Gibelli D, et al. The risk of misinterpreting genital signs of sexual abuse in cadavers; a case report. *Int J Legal Med*. 2013 Sep; 127(5):907-10. PMID: 23832281. <https://dx.doi.org/10.1007/s00414-013-0891-y>.
- 81) Benton SA. Forensic pathology of infancy and childhood. New York: Springer; 2014. Chapter 23, Pediatric sexual abuse; p. 619-66.
- 82) Dalton M. Child sexual abuse. In: Forensic gynecology. London: Royal College of Obstetricians and Gynaecologists Press; 2004. p. 244-9.
- 83) Adams JA, Harper K, Knudson S, Revilla J. Examination findings in legally confirmed child sexual abuse: it's normal to be normal. *Pediatrics*. 1994 Sep; 94(3):310-7. PMID: 8065856.
- 84) Adams JA, Botash AS, Kellogg N. Differences in hymenal morphology between adolescent girls with and without a history of consensual sexual intercourse. *Arch Pediatr Adolesc Med*. 2004 Mar; 158(3):280-5. PMID: 14993089. <https://dx.doi.org/10.1001/archpedi.158.3.280>.
- 85) Berenson A, Heger A, Andrews S. Appearance of the hymen in newborns. *Pediatrics*. 1991 Apr; 87(4):458-65. PMID: 2011421.
- 86) Berenson AB. A longitudinal study of hymenal morphology in the first 3 years of life. *Pediatrics*. 1995 Apr; 95(4):490-6. PMID: 7700746.
- 87) Berenson AB, Somma-Garcia A, Barnett S. Perianal findings in infants 18 months of age or younger. *Pediatrics*. 1993 Apr; 91(4):838-40. PMID: 8464679.
- 88) McCann J, Voris J, Simon M, Wells R. Perianal findings in prepubertal children selected for nonabuse: a descriptive study. *Child Abuse Negl*. 1989; 13(2):179-93. PMID: 2743179. [https://doi.org/10.1016/0145-2134\(89\)90005-7](https://doi.org/10.1016/0145-2134(89)90005-7).
- 89) Heger A, Ticsen L, Velasquez O, Bernier R. Children referred for possible sexual abuse: medical findings in 2384 children. *Child Abuse Negl*. 2002 Jun; 26(6-7):645-59. PMID: 12201160. [https://doi.org/10.1016/s0145-2134\(02\)00339-3](https://doi.org/10.1016/s0145-2134(02)00339-3).
- 90) Myhre AK, Adams JA, Kaufhold M, et al. Anal findings in children with and without probable anal penetration: a retrospective study of 1115 children referred for suspected sexual abuse. *Child Abuse Negl*. 2013 Jul; 37(7):465-74. PMID: 23618719. <https://dx.doi.org/10.1016/j.chiabu.2013.03.011>.
- 91) Stephens BG. Forensic interpretation of blood in the anus. *Am J Forensic Med Pathol*. 2000 Mar; 21(1):93-4. PMID: 10739238. <https://doi.org/10.1097/00000433-200003000-00020>.
- 92) Adams JA. Medical evaluation of suspected child sexual abuse: 2011 update. *J Child Sex Abus*. 2011 Sep; 20(5):588-605. PMID: 21970647. <https://dx.doi.org/10.1080/10538712.2011.606107>.
- 93) Fanton L, Bévalot F, Cartiser N, et al. Postmortem measurement of human chorionic gonadotropin in vitreous humor and bile. *J Forensic Sci*. 2010 May; 55(3):792-4. PMID: 20345805. <https://dx.doi.org/10.1111/j.1556-4029.2010.01331.x>.
- 94) Panella M. Disseminated neonatal herpetic infection simulating abusive anal trauma. *J Forensic Sci*. 2011 Jul; 56(4):1058-61. PMID: 21496019. <https://dx.doi.org/10.1111/j.1556-4029.2011.01791.x>.
- 95) Boos SC, Rosas AJ, Boyle C, McCann J. Anogenital injuries in child pedestrians run over by low speed motor vehicles: four cases with findings that mimic child sexual abuse. *Pediatrics*. 2003 Jul; 112(1 Pt 1):e77-84. PMID: 12837911. <https://doi.org/10.1542/peds.112.1.e77>.
- 96) Muram D, Levitt CJ, Frasier LD, et al. Genital injuries. *J Pediatr Adolesc Gynecol*. 2003 Jun; 16(3):149-55. PMID: 12804940. [https://doi.org/10.1016/s1083-3188\(03\)00042-1](https://doi.org/10.1016/s1083-3188(03)00042-1).
- 97) Boos SC. Accidental hymenal injury mimicking sexual trauma. *Pediatrics*. 1999 Jun; 103(6 Pt 1):1287-90. PMID: 10353944. <https://doi.org/10.1542/peds.103.6.1287>.
- 98) Perlman SE, Hertweck SP, Wolfe WM. Water-ski douche injury in a premenarcheal female. *Pediatrics*. 1995 Oct; 96(4 Pt 1):782-3. PMID: 7567348.
- 99) Hobbs CJ, Wynne JM. The sexually abused battered child. *Arch Dis Child*. 1990 Apr; 65(4):423-7. PMID: 2346335. PMID: PMC1792179. <https://doi.org/10.1136/adc.65.4.423>.
- 100) Adelson L. The pathology of homicide: a vade mecum for pathologist, prosecutor and defense counsel. Springfield: Charles C. Thomas; 1974. 976 p.
- 101) Orr CJ, Clark MA, Hawley DA, et al. Fatal anorectal injuries: a series of four cases. *J Forensic Sci*. 1995 Mar; 40(2):219-21. PMID: 7602281. <https://doi.org/10.1520/jfs15345j>.
- 102) Press S, Grant P, Thompson VT, Milles KL. Small bowel evisceration: unusual manifestation of child abuse. *Pediatrics*. 1991 Oct; 88(4):807-9.
- 103) Byard RW, Donald TG, Rutty GN. Non-traumatic causes of perianal hemorrhage and excoriation in the young. *Forensic Sci Med Pathol*. 2008; 4(3):159-63. PMID: 19291454. <https://dx.doi.org/10.1007/s12024-007-9023-7>.